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Apogamy in Camptosorus rhizophyllus[*]

ELIZABETH DOROTHY WUIST BROWN

(WITH PLATE 2)

The life history of *Camptosorus rhizophyllus* (L.) Link, in both generations, has been studied in detail by Pickett.[†] An ecological study of the prothallia has also been published by the same author,[‡] but no mention is made of observed cases of apogamy either in the field or in cultures. Neither has apogamy been recorded for this fern by any other investigator.

The case of apogamy described in this paper occurred in a culture of the fern which had been made, along with cultures of other ferns, to determine if apogamy could be induced by the modification of external conditions.

MATERIAL

Collections of the fertile fronds of *Camptosorus rhizophyllus* were made during the month of August from plants growing on the limestone cliffs of a glen in the vicinity of Ithaca, New York. They were allowed to dry by exposing the sealed envelopes, in which they had been placed in the field, to sunlight before an open window for about a week. For future use the envelopes were placed in a pasteboard box in the laboratory.

Cultures were made by sowing the spores thickly on 26 c.c. of Knop's full nutrient solution, to which had been added a drop of a 1 per cent. solution of ferric chloride, in small glass capsules. The formula of Knop's solution is as follows:

$MgSO_4$	0.25 gram
$Ca(NO_3)_2$	1.00 "
K_2HPO_4	0.25 "
KCl	0.12 "

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[*] Contribution from the Osborn Botanical Laboratory.

[†] The development of the prothallium of *Camptosorus rhizophyllus*. Bot. Gaz. **57**: 228–238. *pl. 12, 13* + *f. 1–8.* 1914.

[‡] Some ecological adaptations of certain fern prothallia—*Camptosorus rhizophyllus* Link., *Asplenium platyneuron* Oakes. Amer. Jour. Bot. **1**: 477–498. *pl. 49, 50* + *f. 1–19.* 1914.

After the spores had been sown the cultures were placed before an east window and the culture solutions were not renewed.

DEVELOPMENT OF THE PROTHALLIA

Germination began in about one week after the spores were sown and the growth and development of the prothallia were rapid at first, then slower as the amount of nutrient solution in the capsules decreased. The size and shape of the prothallia varied greatly. In the more crowded regions only a few developed into more or less heart-shaped prothallia, while the others in these regions were ribbon-shaped, irregular or branched. In the less crowded regions, especially near the margin of the cultures, more developed into heart-shaped prothallia. All the prothallia were smaller than when developed in cultures where the nutrient solution was renewed from time to time. Many of the prothallia showed the great irregularity of margin and the various types of marginal outgrowths described by Pickett. Antheridia in large numbers developed on the ribbon-shaped and branched prothallia, while the heart-shaped prothallia developed meristem which bore first antheridia and later archegonia. The latter evidently did not function, as no normal sporophytes were formed, although large quantities of antherozoids were present.

In about ten weeks after germination began, an apogamous sporophyte was found on one of the larger prothallia near the margin of the culture, in one of the less crowded regions. In a few weeks after the apogamous sporophyte developed, the nutrient solution in the capsules having been exhausted, new nutrient solution was added. The stimulating effect of this new solution could soon be noted by the appearance and growth of the prothallia and by the development of a few normal sporophytes. However, this stimulating influence seemed of short duration, as the culture soon began to decline. A number of the prothallia in the more crowded regions turned brown and appeared dead, while no more sporophytes were produced. When the solution was again exhausted new was added and again the stimulating influence could be noted, but it was not as noticeable as it had been before. The prothallia showed increased vigor, although no more sporophytes developed. Many of the prothallia which appeared dead gave rise to proliferations which developed into prothallia bearing antheridia. Thus by adding new solution from time to time when the old became exhausted the culture has been kept living up to the present time. Some of the prothallia appear normal, having a meristem bearing both antheridia and archegonia, while others have given rise to proliferations which in turn bear antheridia.

DESCRIPTION OF THE APOGAMOUS GROWTH

The prothallium on which the apogamous outgrowth occurred was somewhat irregular in shape and only one cell in thickness (FIG. 1, P). No sinus was present and at the point where one usually occurs in larger and older prothallia a marginal structure, or lobe, had formed (FIG. 1, L).

The apogamous outgrowth began its development as a swelling in the region of the prothallium where the meristem begins to form. This swelling continued to grow, forming a cylindrical process several cells in thickness which became somewhat narrower as it developed. After growing for some time in this manner reversion to a narrow prothallus-like structure, only one cell in thickness with an irregular broadened apex (FIG. 1, AO), took place. At one point a branch, irregular in shape and itself showing a slight tendency to branch, developed (FIG. 1, B_1). On the opposite side of the prothallus-like structure, near the apex, another branch was formed. This branch-prothallium was somewhat elongated, one cell in thickness with a broad slightly heart-shaped apex (FIG. 1, B_2). Rhizoids developed from some of the marginal cells near the broadened apex (FIG. 1, R). On one side of the elongated part of this branch-prothallium, the marginal and adjacent cells were smaller and more numerous. From this region an archegonium, normal in appearance, developed (FIG. 1, A_1). The venter of the archegonium was not imbedded in the tissue of the prothallus but the whole archegonium extended beyond the margin of the prothallus (FIGS. 2, 3).

Two archegonia developed on the apogamous growth near its point of origin (FIG. 1, A_2) and just beyond this point a cluster of tracheids was formed in the tissue of the outgrowth (FIG. 1, T). As well as could be observed, owing to their imbedded position, these tracheids resembled those of a normal sporophyte.

DISCUSSION

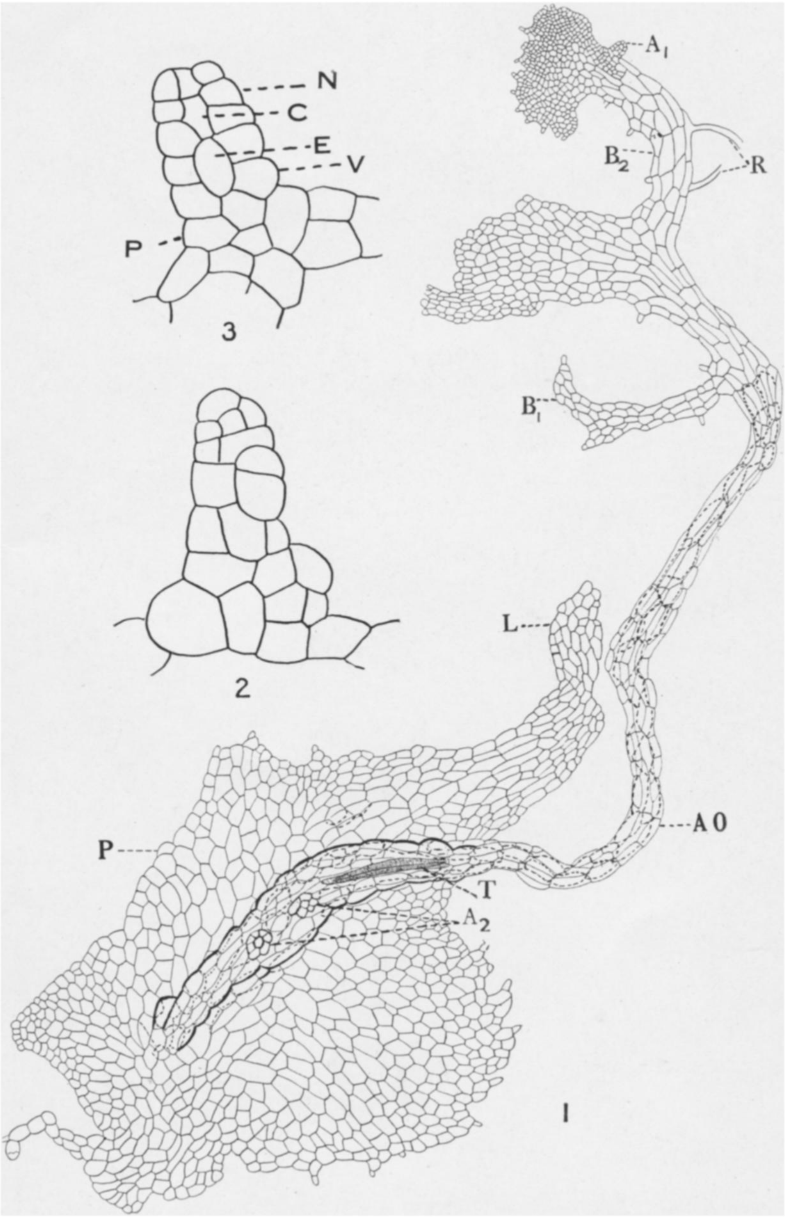
Experimental data on induced apogamy would seem to indicate that bright light and insufficient moisture for fertilization were the controlling factors for the forms studied. In this particular case an insufficient food supply seems of greater importance than these two factors for the following reasons. Apogamy was never observed in other cultures of this fern under the same light conditions where the nutrient solution was renewed frequently. The prothallium upon which the apogamous outgrowth occurred, while developing near the margin of the culture, was crowded by other prothallia and shaded by them. Sufficient moisture for fertilization was available, as the prothallia developed upon a liquid medium. Later, when the nutrient solution was renewed, thereby supplying sufficient nourishment, normal sporophytes developed in the culture, although conditions of light and moisture remained unchanged. The fact that the part of the apogamous outgrowth which was last to develop showed a reversion from a more or less complex structure several cells in thickness bearing tracheids to a simple prothallus-like one only one cell in thickness and branched indicates a lowered vitality of the outgrowth. Goebel considers a reversion to a juvenile form as being the result of unfavorable conditions. The unfavorable condition in this instance was doubtless an insufficient food supply. However, the effect of this factor in inducing apogamy will be discussed at a greater length in a future paper on induced apogamy in *Phegopteris polypodioides* Fée.

Since only one case of apogamy was observed in the experimental cultures, it would seem that apogamy is of very rare occurrence in *Camptosorus* and not easily induced.

Explanation of plate 2

FIG. 1. Prothallium showing apogamous outgrowth, × 120: *P*, prothallium; *AO*, apogamous outgrowth; A_1, A_2, archegonia; *T*, tracheids; B_1, B_2, branches; *R*, rhizoids; *L*, lobe of prothallium.

FIGS. 2, 3. Surface view and median optical section view of the archegonium borne on the margin of the branch of the apogamous outgrowth, × 275: *N*, neck; *C*, canal; *V*, venter; *E*, egg; *P*, prothallium.



BROWN: APOGAMY IN CAMPTOSORUS RHIZOPHYLLUS